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Defensive Behavior of the Hognose Snake (Heterodon platyrhinos)

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DEFENSIVE BEHAVIOR OF THE HOGNOSE SNAKE (*HETERODON PLATYRHINOS*)

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BY

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Fourteen out of sixteen Heterodon platyrhinos eggs were hatched in late August, 1973. The immature snakes were manually stimulated and the resultant bluffing and death-feigning behaviors were observed. All of the experimental snakes bluffed, but only three out of ten feigned death. The major components of the bluffing behavior are spreading the neck, hissing, and striking. Death-feigning is preceded by contortions and shows variations in the positions of the mouth and tongue. The newly-hatched snakes exhibited both bluffing and death-feigning, indicating that the behaviors are innate.

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INTRODUCTION AND LITERATURE REVIEW

The snakes of the genus Heterodon are interesting because of their unusual behavior. Their bluffing and death-feigning behavior has excited much comment and speculation from biologists and non-biologists alike. It has caused these snakes to be the subject of much unwarranted fear and abuse. The fearsomeness of the behavior is reflected in some of the common names applied to this genus, such as puff adder, blowing viper, and spread-head. Much of the literature on Heterodon consists of a brief description of the bluffing and death-feigning behavior as it is casually observed. The present study of H. platyrhinos was undertaken to observe the various components of these behaviors, their duration, and sequence.

When disturbed or molested, the snake will usually bluff first. While bluffing, the front half of the body inflates to twice its normal size, causing the markings on the body to stand out vividly. Air is expelled from the lungs with a loud hiss. If stimulation continues, the snake plays dead by lying on its back with the mouth open (Oliver, 1955).

One of the most complete descriptions of hognose snake behavior is given by Edgren (1955). He divides the behavior

into two stages: the kinetic and akinetic phases. During the kinetic or bluffing phase the snake hisses and makes "mock strikes" by thrusting the anterior part of the body forward while the body is expanded with air. He states that the lateral flattening of the body and head is allowed by a hinge mechanism of the anterior ribs which enables them to be expanded laterally almost at a right angle to their normal position. After a period of this behavior, the snake begins to writhe violently with the mouth gaping and rubbing against the ground. The snake then lies still, belly-up, mouth open and tongue protruding. After some time the snake raises its head slightly and observes the area. If nothing disturbs it, it will turn over and crawl away. If something moves, it will remain motionless in this position. Edgren found that during the "mock strikes" of H. platyrhinos, the mouth was held slightly open. He states that according to Karl Schmidt, H. nasicus gapes widely during this phase. The nasicus individuals which Edgren collected, however, would only hide their head under their coils.

The preceding illustrates the disagreement among various authors concerning specific aspects of these behaviors. One of the components for which there is much variation in description is the position of the mouth. Smith in Wright and Wright (1957) states that the mouth is so wide open that it gives the appearance of a dislocated lower jaw as the snake darts at the object causing the reaction. Spaid (1903) also mentioned the position of the

jaws, but during death-feigning rather than bluffing. He says that the mouth is wide open with the tongue protruding and that many people believe the snake commits suicide by throwing its jaws out of place. Ditmars (1910, 1936) states that the mouth is closed while bluffing and that the snake cannot be induced to bite. If bluffing does not "work", then the snake opens its mouth and goes into convulsions prior to the death-feign. Schmidt and Davis (1941) state that mouth-gaping is characteristic of H. nasicus, but not of H. platyrhinos.

Most authors also include in the description of the death-feigning that a snake will always turn back onto its back if put in the crawling position. They interpret this as a "mistake" on the part of the snake for giving itself away (Ditmars, 1936; Curran and Kauffeld, 1937; Schmidt and Inger, 1957; and Harrison, 1971). However, Munyer (1967) disagrees with the assumption that it is a "mistake" for the snake to always turn onto its back. His experiments with H. platyrhinos in water indicate that this same response may not be a "mistake". Dead snakes floating belly-up in water always return to this position if they are disturbed. He speculated that perhaps the rolling over action had previously evolved for use in water and is some type of vestigial behavior.

However, Munyer (1967) and Myers and Arata (1961) realize that there is much variation, both individual and interspecific, in all aspects of the behavior, including mouth-gaping and rolling over. Myers and Arata observed H. simus, for which there were no

previously recorded observations as there were for other species of Heterodon. This species does not seem to be as reactive as other species, most notably H. platyrhinos. The snake they observed would not roll over onto its back after being righted, once its writhing movements had ceased. It would turn back over only during the early stages of thrashing. This snake did open its mouth widely during the bluffing act, whereas a second individual did not.

The cause of this behavior has aroused much speculation. Hulme (1951) described death-feigning in Ringhals cobras and suggests that it is due to "fainting". Parker (1963) says that playing dead is "some kind of fright reaction". Minton (1944) has suggested that the activity may be volitional, and compared it to human narcolepsy. Hartman (1950) suggests that akinesia is caused by chemical substances diffusing from nervous centers. These would later be destroyed by enzymatic or oxidative action.

Edgren and Edgren (1955) did an experiment to test the effects of certain chemicals on the behavior. They administered doses of the adrenal hormone epinephrine, nor-epinephrine, and acetylcholine to H. platyrhinos. Even though large quantities were injected, the actions were not simulated. The failure of epinephrine to stimulate the action suggests that the adrenal medulla is not involved. ACh failure tends to exclude the parasympathetic nervous system and general stimulation of skeletal muscle. The failure of nor-epinephrine implies that the sympathetic nervous

system is not the mediator of the behavior. They concluded, therefore, that the behaviors are probably central humoral or reflex effects. However, Smith and White (1955) found a wide disparity between Heterodon and other North American snakes in the relative size of adrenal glands. Those of Heterodon are greatly enlarged compared to other species. They hypothesized that this is an adaptation to a diet of toads. Since hognose snakes are immune to the poisonous secretions of the skins of toads which contain epinephrine, their own adrenals must be relatively large to produce the quantity of epinephrine necessary to have any effect in the normal functioning of these animals. Therefore, they would have also had a high resistance to the doses of epinephrine given by Edgren and Edgren.

Concerning the behavior of very young Heterodon, the literature is more sparse. Most of the field observations and experiments done on hognose snakes have used adult snakes. Hay (1892) made some observations on the hatching of H. platyrhinos. From the moment of hatching, all were active and displayed many of the characteristics of the adults. Some would strike at an approaching finger, accompanied by a hiss. One would sometimes flatten its head and rear up the anterior third of its body. Out of fifteen young, only two or three would death-feign when provoked.

Kennedy (1961) hatched 37 snakes from 99 eggs and found that some of the young feigned death when he picked them up to measure

them. One of these had been out of the egg less than an hour when it feigned death. He concluded that this behavior is not learned or acquired with age. Monro (1949), studying H. nasicus, stated that defensive behavior was not noted until several days after hatching. Raun (1962), working with H. platyrhinos, noted that in nearly every instance the approach of a hand elicited defensive behavior in new-born snakes. Some of the young bluffed and some feigned death. One feigned death while only partially out of the shell. He states that the shape and size of the object that acts as a stimulus may be critical, since the movement of small objects, such as toads, did not evoke defensive responses. After three or four days of handling, the death-feigning reaction was lost and after ten days they had lost all traces of the behavior, including bluffing.

An alternative behavior was described in great detail by Davis (1946). He described the pattern of movements involved in the burrowing of Heterodon. When the snake did not burrow voluntarily, he would tap it with a stick. After exhibiting the usual bluffing behavior, it would begin to bury itself in the sand as an escape reaction, rather than death-feigning.

MATERIALS AND METHODS

A gravid female hognose snake, Heterodon platyrhinos, which had been captured in late spring, laid sixteen eggs on July 23, 1973. The eggs were taken from the snake and kept in two-pound cans with moist paper toweling at a constant temperature of 20° C until hatching. Water was periodically added to keep the paper towels moist. The lid of each can was perforated with numerous small holes to allow air to enter. Fourteen of the eggs hatched over a four-day period from August 25 to August 28. The remaining two eggs never hatched.

Each snake was placed in a separate gallon jar with a screen lid. The jars were laid on their sides and filled with five cups of sand to a depth of 1½-2 inches. A petri dish of water was provided. Each snake was visually isolated from the other snakes. The behavior of the snakes on the day of hatching was observed for any signs of bluffing or death-feigning. The general locomotor activity of each snake was noted every other day for a week.

Ten snakes were selected at random to serve as the experimental group. These animals were tested every other day for bluffing and death-feigning. A 12 x 15 inch cardboard box was used to contain the snakes during testing. Each snake was placed individually in

the box and prodded with the blunt end of a probe. The prodding was continued for two minutes or until ten seconds after the snake started to death-feign. The prodding was continued for ten more seconds after the beginning of death-feigning to stimulate a complete death-feigning display. All observations were recorded on a data sheet listing these components of the bluffing behavior: inflating; spreading; hissing; and striking. Also listed were aspects of death-feigning: contortions; turning over; completeness of death-feigning; and position of mouth and tongue. Other behaviors listed were escape behavior, evacuation, and curling. Latency for bluffing and for death-feigning was also recorded. The experiment consisted of fifty test periods over a period of 100 days.

The remaining four snakes served as controls. These snakes were left completely alone except for feeding and watering. They were then provoked at the conclusion of the experiment to determine if there was any difference in behavior between those that had been provoked to the point of bluffing and/or death-feigning regularly and those that had not.

After the completion of the first experiment, all of the snakes were again tested in the cardboard box by placing an adult male mouse in the box with the snake. This animal might simulate a predator of the appropriate size for these young snakes. The observation period was five minutes every other day. A glass was placed over the box to prevent the mouse from escaping. Behavior

of the snake and mouse was recorded on data sheets. There were eight testing periods over a period of fifteen days for each snake.

RESULTS

On the first day of hatching, eight snakes were partially out of their eggs when the paper towel was removed. One of these pulled its head back into the egg completely and three others death-feigned. Two of these only briefly feigned death, whereas the third snake death-feigned for five minutes. Of the fourteen snakes that hatched, all of them flattened their necks when picked up during the transfer to isolating jars. One feigned death for thirty seconds inside the jar.

During the one-week observation period before the first experiment, none of the snakes seemed to be weak or sick. The general activity of each snake was at nearly the same level, except snake #6 was always buried under the sand during each observation period.

During the experiments, either prior to or concurrent with bluffing behavior, escape behavior was almost always apparent (fig. 1). In those cases in which the snake did not make an attempt to crawl away, the snake would coil itself into a ball (fig. 2). Occasionally, a snake would remain curled up with its head tucked under its body, to the exclusion of any other type of behavior (fig. 3). Fecal material was usually exuded also. All

Fig. 1 Immature Heterodon platyrhinos: escape behavior with moderate degree of neck spread.

Fig. 2 Immature Heterodon platyrhinos: coiling and inactive, except for slight neck spread.

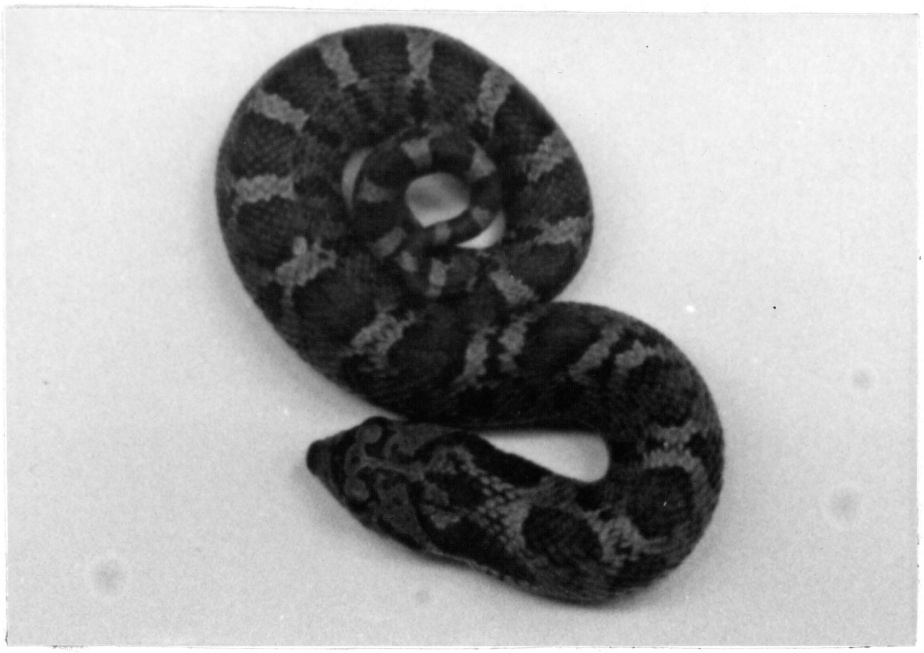
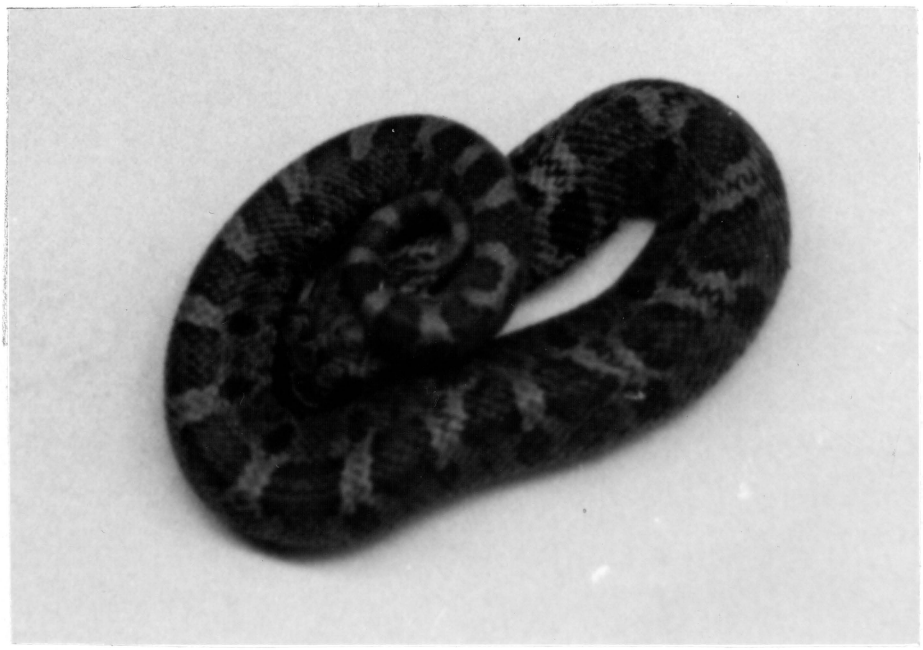
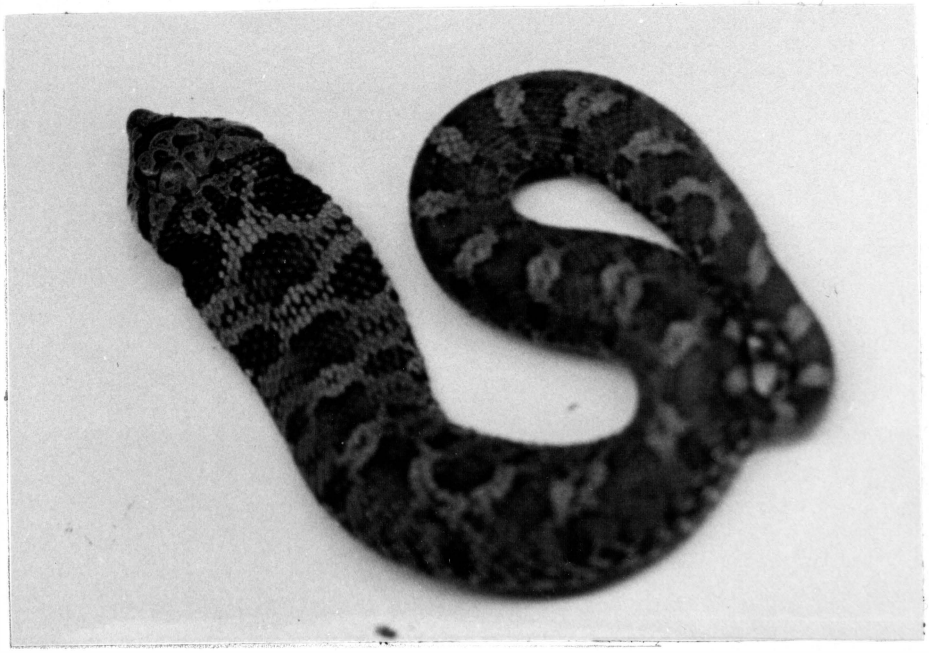


Fig. 3 Immature Heterodon platyrhinos: coiling and tucking the head under the body.

Fig. 4 Immature Heterodon platyrhinos: wide neck spread, showing dorsal pattern.





of the snakes exhibited some degree of bluffing behavior. Inflating the body with air and spreading the anterior ribs to flatten the head and neck are the first steps in the bluff sequence (fig. 4). Letting the air escape with a hissing noise is the next most frequent aspect of bluffing. The least frequent is keeping the anterior part of the body raised and making forward thrusts with the head. In all cases, these thrusts were made with the mouth closed. These later stages of bluffing are accompanied by the earlier stages. That is, during the "mock strikes" the neck is still spread and each strike is generally, but not always, accompanied by a hiss.

Of the ten experimental snakes, only three death-feigned during the experimental situation. Prior to death-feigning, the snake begins writhing and twisting itself, turning over and over with its mouth open and tongue hanging out (fig. 5). Then the snake lies completely still, belly-up. The mouth may be either open or closed and the tongue either in or out during the actual death-feign (figs. 6, 7, 8). If the mouth is open and the tongue out, after a variable length of time the snake will slowly pull the tongue back and then gradually close its mouth. Except for this movement, the snake may remain motionless for several more seconds or minutes. The snake will then slowly raise just its head and flick out its tongue (figs. 9, 10, 11). Sometimes the snake will remain in this position for several seconds or minutes (fig. 12). The snake then slowly turns onto its ventral surface.

Fig. 5 Immature Heterodon platyrhinos: contortions prior to death-feigning.

Fig. 6 Immature Heterodon platyrhinos: death-feigning; mouth closed, tongue in.

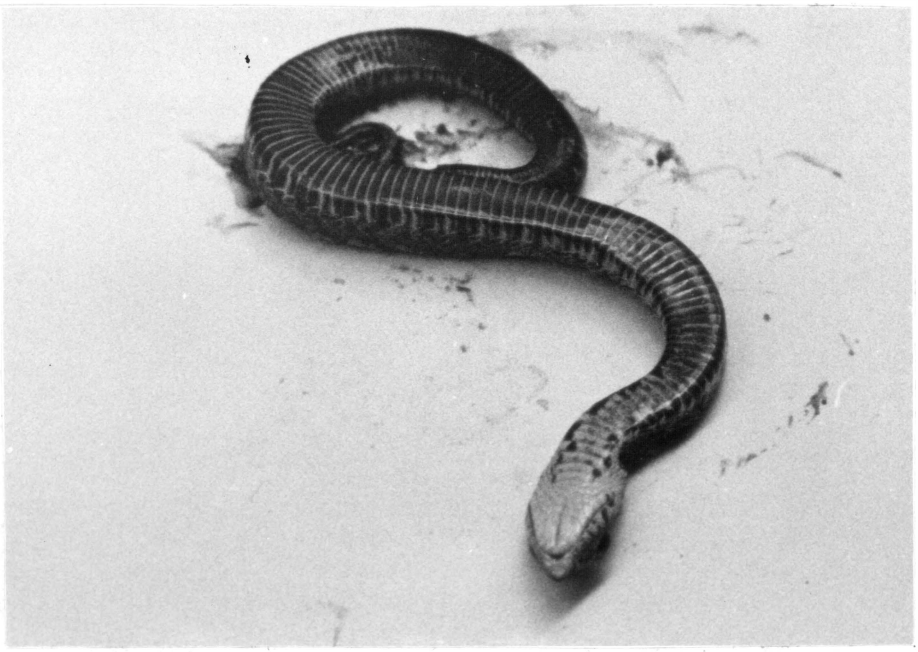
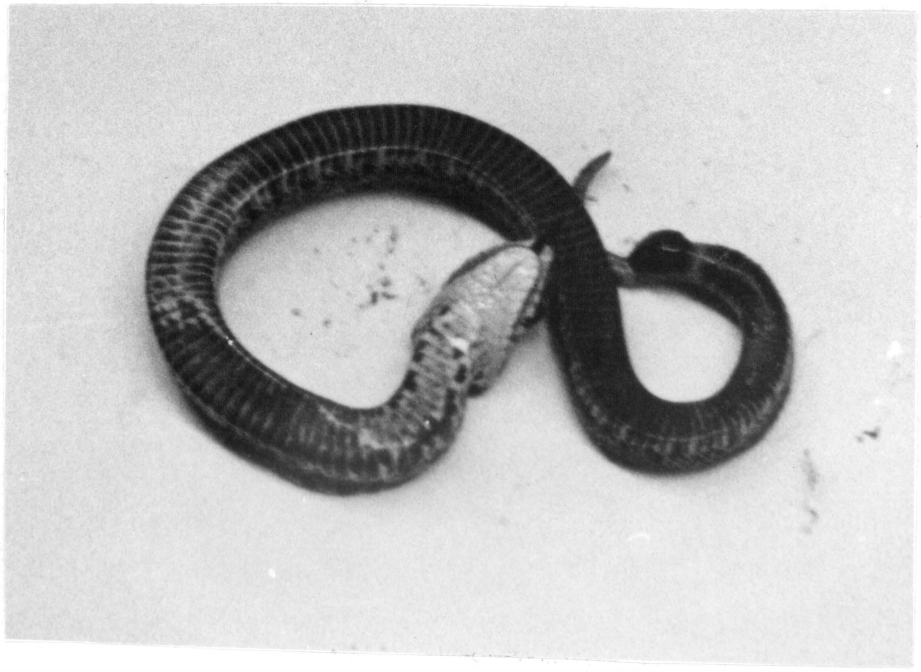


Fig. 7 Immature Heterodon platyrhinos: death-feigning; mouth open, tongue in.

Fig. 8 Immature Heterodon platyrhinos: death-feigning; mouth closing, tongue being drawn in.

Fig. 9 Immature Heterodon platyrhinos: beginning to come out of death-feign, flicking tongue.

Fig. 10 Immature Heterodon platyrhinos: beginning to come out of death-feign, head slightly raised, but motionless except for tongue flicking.



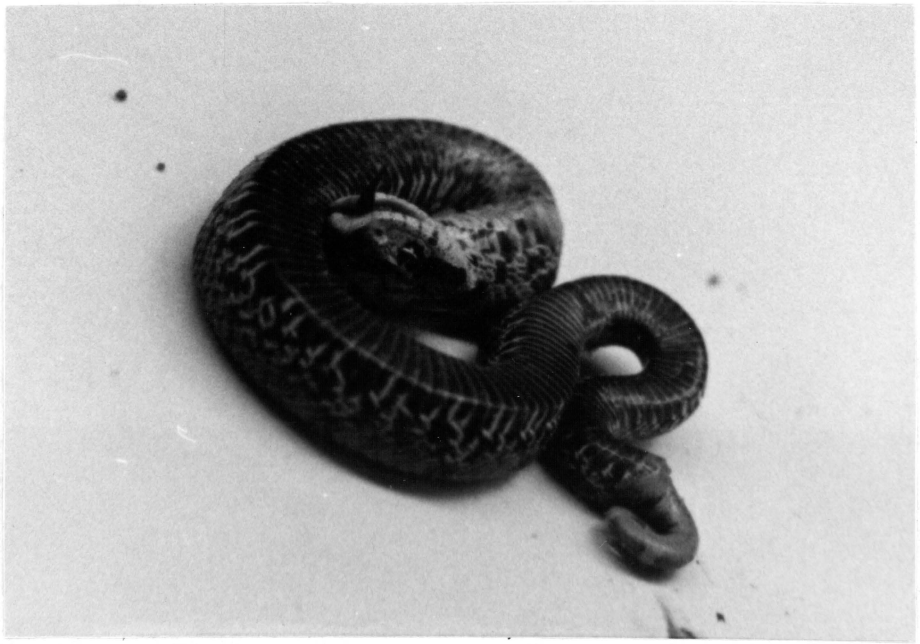
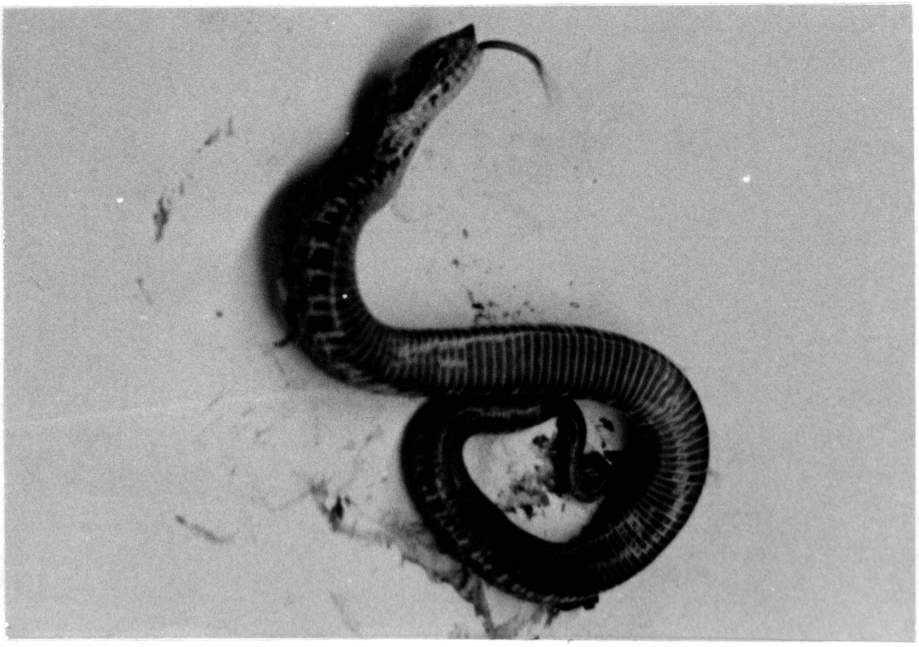
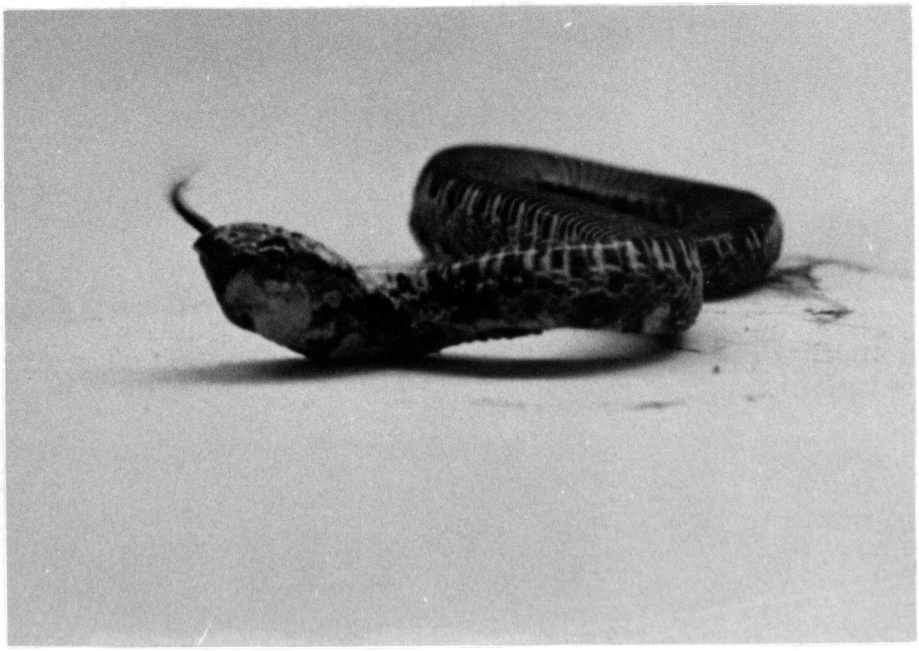


Fig. 11 Immature Heterodon platyrhinos: coming out of death-feign, rolling onto side.

Fig. 12 Immature Heterodon platyrhinos: after death-feign, lying with anterior part of body twisted onto side, head raised.





There is much individual variation for both death-feigning and bluffing. The shortest death-feign during the experiment was 20 seconds and the longest was 13 minutes 50 seconds. Snake #6 feigned death only for the first five test periods. Snake #12 death-feigned only for the first two trials and then lost the behavior pattern. Snake #7 never lost the behavior and death-feigned every trial, except the first one. This snake also had the longest death-feign. However, it died when 68% of the trials had been completed. Latency for death-feigning ranged from 12 seconds for snake #6 on the first trial to 2 minutes for snake #7 on the fifth and sixth trials.

All of the bluffing behavior persisted throughout the experiment for all of the individuals. Spreading was the most prevalent behavior for all snakes. There was little or no latency for spreading. It was apparent in all the snakes beginning with the first trial. On the other hand, only four snakes hissed at all during the first three trials. Two of these four were death-feigners, also. One snake did not begin hissing until trial thirteen, but continued the behavior thereafter. Most of the snakes did not begin hissing until trial 8-10. Striking was even less common in early trials. Only three snakes made strikes on the first trial. These were the same snakes that hissed. Most of the snakes began striking at approximately the same time they started hissing, but they did so less consistently. The percentage of trials that each snake exhibited these behaviors is indicated in

Table 1.

After the first experiment was completed, the controls were tested the same way to see if there was any difference between these and those that had been in the experiment for the past 100 days. One of the controls died before the experiment ended. Of the remaining three controls, two bluffed and feigned death and the other one showed all aspects of bluffing, but no death-feigning.

When the snakes were tested individually with a mouse, there was no difference between the pattern of bluffing responses and those of the first experiment. The mouse, however, did not elicit death-feigning behavior from any of the snakes.

	BLUFFING			DEATH-FEIGNING
Snakes	Spread	Hiss	Strike	
1	100%	100%	100%	
2	100%	65%	88%	
3	88%	76%	50%	
4	100%	85%	29%	
6	100%	94%	91%	15%
7	100%	100%	65%	96%
10	100%	9%	3%	
12	100%	79%	44%	6%
13	82%	38%	38%	
14	100%	29%	15%	

Table 1. Percent of trials in which the behaviors were displayed at least once.

DISCUSSION

Bluffing and death-feigning are innate behaviors as evidenced by the three young snakes which death-feigned while only partially out of the egg. The bluffing and death-feigning pattern was basically the same as that of the adults. This agrees with the findings of Hay (1892), Kennedy (1961), and Raun (1962). On the other hand, Monro (1949) stated that these behaviors are not exhibited until several days after hatching in Heterodon nasicus. The results of the present study indicate that although the behavior is innate, certain aspects of the pattern do change with an increase in age. Hissing and striking appear at a later age usually than spreading the neck. Only two of the ten snakes hissed on the first trial and only one snake hissed and made strikes on the first trial. Yet all of the snakes hissed and struck before the experiment was completed. The snakes are at least capable of eliciting all aspects of bluffing and death-feigning from the time of hatching. However, it seems that after they are slightly older, they more readily hiss and strike. Counteracting this greater display with age is the tendency of these snakes to lose the behavior in captivity. Of three death-feigning snakes, two lost the behavior fairly rapidly and the remaining snake continued

to death-feign until its death. This most reactive snake was the first snake of the group to die. Perhaps the fact that it was more stressed by the experiment than the other snakes could partially account for its death.

The differences in responses as reported by different authors could be due to different levels of stimulation rather than actual differences in innate behavior of individuals. Many of the authors do not specify what type of stimulation caused the behavior. Raun (1962) speaks of the approach of a hand, Kennedy (1961) picked them up, and Hay (1892) "lightly struck them". Often, an author will simply state that "upon being provoked..." without mentioning the specific stimulus causing the provocation. In the present study, physical contact was essential to provoke a snake to death-feign whereas the bluffing response required no physical contact from the highly reactive snakes. In those snakes that bluffed without physical contact, the intensity of the response increased with prodding. There seems to be a difference in the threshold of response for each of the aspects of bluffing and death-feigning and these thresholds vary from one individual to another. It is the author's opinion that if enough stimulation were applied, every hog-nose snake could be induced to death-feign. The innate ability is there in all snakes, but some have higher thresholds than others.

After the experiment was terminated, there was an occurrence exemplifying that higher thresholds need stronger stimuli. A

snake that had been extremely reactive in bluffing, eliciting all the aspects of the behavior every time, could not be induced to death-feign by prodding during the entire experiment. Two months after the end of the experiment, this snake was force-fed for the first time. Subsequent to the attempt to feed it, the snake death-feigned for the first time and remained motionless for thirty-five minutes. Force-feeding was a stronger stimulus than prodding, enough to reach this individual's threshold.

When the controls were tested at the end of the experiment, two out of three feigned death. The higher proportion of death-feigners could be due to chance, since the number of individuals involved was small. Another possibility is that the controls were more responsive because they were older at the time of testing. Or the greater responsiveness could be due to the fact that these snakes had not been disturbed previously and therefore reacted more strongly. The experimental snakes may have become habituated to the stimulation. Myers and Arata (1961) stated that the specimen they observed, when not disturbed for a week, would react with renewed vigor.

In the second experiment with the mouse as the stimulus, no death-feigning was elicited. This could be attributed to the limited physical contact between the mouse and the snake. The mouse did not respond to the snake's bluff and continued to make exploratory movements around the box, inadvertently stepping on the snake occasionally. The snakes reacted by bluffing, but were

not stimulated to death-feign.

Just as the mice elicited bluffing displays from the snakes, so did the cricket frogs which were placed in the jars with the snakes as food. This is opposed to what Raun (1962) found. He stated that the movement of small objects such as toads was ignored by the snakes, and he concluded that the shape and size of stimuli may be a critical factor. In the present study, the introduction of frogs into the jars caused the snakes to bluff. Even after the experimenter withdrew from the area of the jar, the snakes continued to bluff as the frogs jumped around the jar, even jumping on top of the snakes. The behavior continued until their olfactory senses made the snakes aware of the frogs as food items. Once this distinction was made, the snakes stopped bluffing and began chasing the frog. They seemed to only recognize moving objects, as they would many times crawl past the frog if it was motionless, often with their mouth wide open.

Perhaps the snakes which Raun studied did not bluff at toads because they had higher thresholds of response than those of the present study. His snakes stopped death-feigning after three or four days and stopped bluffing after ten days. It is his impression that death-feigning is not of equal selective advantage with bluffing, but is a secondary pattern "resorted to" after bluffing has failed.

In contrast to Raun's snakes which lost all aspects of the behavior so rapidly, Edgren (1955) reported a snake that continued

to death-feign in captivity for over a year. This snake must have had a very low threshold of response. Being in captivity tends to raise the threshold for most snakes. This increases the difficulty of laboratory study, since so few snakes continue to death-feign in captivity.

Munyer's (1967) study of death-feigning in water led him to suggest that the rolling over action of snakes that are righted onto their ventral surface may be some type of vestigial behavior originally evolved for use in water or used by snakes disturbed in water now. The evidence is lacking to support this theory. Myers and Arata (1961) found that H. simus does not turn back over when righted, as H. platyrhinos and H. nasicus do.

During the tests in which a snake did not exhibit much bluffing behavior, the response was usually that of burrowing. The snake would try to hide its head under its own body. The snakes which spent much of the time buried under the sand in the jars were also the ones which buried their heads during the experiment. This seems to be an alternative escape reaction which is more apparent in those snakes which have higher thresholds for bluffing and death-feigning.

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